

Achieving Subnanosecond Delays Using Feedback with the Current Switch, L. Weiss and T. S. Jen, *IEEE Journal of Solid-State Circuits* SC-1, No. 2, 86-94 (December 1966). Beginning with the basic current switch, the application of feedback is explored to achieve faster switching speeds with greater fanpower. This paper qualitatively describes the evolution of an integrated circuit that requires only one power supply and has, through the introduction of time-dependent negative feedback, achieved subnanosecond propagation delays with the ultimate speed limited primarily by the device used, the component tolerances, and the range of the operating environment. Higher input impedance, better stability and noise tolerance are also by-products of the circuit. From this analysis, a general logic family for high-speed computer applications may be derived.

Adaptive Data Compression, C. A. Andrews, J. M. Davies, and G. R. Schwartz, *Proceedings of the IEEE* 55, No. 3, 267-277 (March 1967). Data compression techniques are classified into four categories which describe the effect a compression method has on the form of the signal transmitted. Each category is defined and examples of techniques in each category are given. Compression methods which have received previous investigation, such as the geometric aperture methods, as well as techniques which have not received much attention, such as Fourier filter, optimum discrete filter, and variable sampling rate compression are described. Results of computer simulations with real data are presented for each method in terms of rms and peak errors versus compression ratio. It is shown that, in general, the geometric aperture techniques give results comparable to or better than the more "exotic" methods and are more economical to implement at the present state of the art. In addition, the aperture compression methods provide bounded peak error which is not obtainable with other methods. A general system design is given for a stored-logic data compression system with adaptive buffer control to prevent loss of data and to provide efficient transmission of multiplexed channels with compressed data. An adaptive buffer design is described which is shown to be practical based on computer simulations with five different types of representative data.

Addendum to "Stronger than Uniform Convergence of Multistep Difference Methods," B. Dejon, *Numerische Mathematik* 9, 268 (1966). This paper fills a gap which remained in "Stronger than Uniform Convergence of Multistep Difference Methods," *Numerische Mathematik*, 8, 29 (1966), namely to show that from the stability of the homogeneous difference operator on the particular bases chosen in the solution space one can infer its stability on the whole solution space.

On the Application of the Process of Equalization of Maxima to Obtain Rational Approximation to Certain Modified Bessel Functions,* I. Gargantini, *Communications of the ACM* 9, No. 12, 859-863 (December 1966). The second Remes algorithm as originally established for polynomials, may converge or not when the approximating functions are rational. However, the few results known in this domain show how efficient the algorithm can be to obtain approximations with a small error, much more than in the polynomial case, in which the best approximation can be very nearly approached directly by a series development. The aim of this paper is to investigate the limitations of the applicability of certain extensions of the algorithm to the case where the approximations are rational as well as to present some numerical results.

* The work reported in this paper was started when the author was numerical analyst at Euratom, C.C.R., Ispra, Italy.

Complete Sets of Functions of Two and Three Binary Variables, V. Kudielka and P. Oliva, *IEEE Transactions on Electronic Computers* EC-15, No. 6, 930-931 (December 1966). A catalog of all nonredundant complete sets of functions of two and three binary variables is presented in the form of a table.

Abstracts

from recent
papers by
IBM authors

Computer-Aided Design for Integrated Circuits, J. S. Koford,* P. R. Strickland, G. A. Sporzynski, and E. M. Hubacher, *Graphic Science* 9, No. 1, 18-20 (January 1967). This paper describes a computer program that utilizes a graphic data processing system to aid in the design of mask artwork for hybrid integrated circuit modules of the type used in IBM SYSTEM/360 Data Processing Systems. The system includes a small digital computer connected to a large-screen buffered display equipped with a light pen. A draftsman uses the light pen to assemble a circuit schematic on the display screen; simultaneously, a description of the schematic is entered into the computer memory. Thereafter, the draftsman can use the light pen to lay out detailed artwork for fabrication on the circuit mask, subject to automatic checking against the stored schematic. When the layout on the display screen is complete, the corresponding mask artwork will be drawn by the computer via its digitally-controlled plotter. The graphical manipulations on the display screen, the automatic checking operations, and the control of the digital plotter are all part of a FORTRAN program that employs graphical subroutines to communicate with the light pen, display, and plotter.

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A Computer Program System to Facilitate the Study of Technical Documents, D. G. Bobrow,* R. Y. Kain,** B. Raphael,*** and J. C. R. Licklider, *American Documentation* 17, No. 4, 186-189 (October 1966). The purpose of this paper is to describe a system, consisting of a digital computer and a computer program, intended for exploration of man-machine interaction and computer assistance to man in the study of technical documents. The system provides a physical study situation that includes a desk, an electric typewriter, a display screen, and a light-sensitive pointer or stylus ("light pen"). The user of the system, whom we shall call "the student," requests services and controls operations by typing command characters or symbols on the typewriter or by touching illuminated areas of the display screen with the light pen. The computer and program system, which we call "Symbiont" because we hope to develop it into a truly symbiotic partner of the student, displays information to the student via the typewriter or the display screen. The display screen, which is a 10-inch square area on the face of a cathode-ray tube, represents alphanumeric symbols and graphs. Whenever part of a displayed pattern is touched by the tip of the light pen, the computer can tell what part was touched and when. The combination of computer-controlled cathode-ray display and computer-signaling light pen is a convenient and flexible arrangement for man-computer communication. Symbiont is an early stage of what we hope will be a continuing evolution. However, a sufficient set of functions has been implemented to lead us to take stock and gain experience in their use before modifying existing functions or adding new ones. Inasmuch as Symbiont is an exploratory tool, for use mainly by students who are at the same time experimenters, we have not considered it necessary to perfect or polish. For example, the display flickers. With the aid of character-generation and display-buffering equipment, we could achieve a steady display: the technology is far enough advanced to fulfill the display function well. At present, however, the equipment required for flicker-free display is expensive, and we prefer to put available funds into other things. Our reasoning is that, in due course, good, steady displays will become relatively inexpensive, and in the interim we can make allowances for a bit of flicker. The same argument applies to text storage capacity, text searching rate, and production of permanent copy. In short, our aim has been to realize several interesting functions now, even though in ways for which certain allowances have to be made, in order to gain early experience in using the functions and to provide a basis for practical system design when advances in technology make it possible to implement the functions effectively and economically.

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Computer Simulation of Stepping-Motor Performance, J. R. Dailey, *Electro-Technology* 79, No. 3, 60-64 (March 1967). Conventional analog-computer techniques are compared to the PACTOLUS and DSL/90 digital-computer programs as methods for analysis of stepping-motor performance.

On Connecting Modules Together Uniformly to Form a Modular Computer, E. G. Wagner, *IEEE Transactions on Electronic Computers* EC-15, No. 6, 864-873 (December 1966). A modular computer may be informally defined to be a device consisting of a large (or infinite) number of identical circuit modules connected together in some uniform manner. This paper is concerned with making the concept of "connected together in a uniform manner" mathematically precise. Uniformity of connection in a modular device is first defined in terms of the linear graph whose vertices correspond to the modules and whose edges correspond to the cables connecting them. It is shown that the class of graphs satisfying the definition is precisely the class of group-graphs; that is, the vertices correspond to the elements of a group G , and there is a finite subset G_0 of G ($1 \in G_0$) such that $\{g, g'\}$ is an edge of the graph if, and only if, there exists g_0 in G_0 such that $g' = gg_0$. It is then shown that restricting the group G to be Abelian restricts the patterns of simultaneous activity which may occur within the computer.

The Contact Problem in Solid-Ink Printing, H. D. Conway* and R. R. Schaffer, *Experimental Mechanics* 7, No. 1, 15-22 (January 1967). An analysis is made of the print-quality characteristics of multi-copy printing in which a rigid type font indents several layers of paper and carbon paper resting on a rigid platen. Particular attention is given to determining the contact-pressure distributions for two indenter shapes and for layers of various thicknesses. Stress distributions in the layers are computed and, using a stress-failure mechanism for solid ink, the stress distributions are found to agree well with optical-print density and reflectance measurements obtained from experiments.

* Cornell University and Consultant to the IBM Corporation.

Contribution to the Computer Calculation of High-Speed Plate Cams, W. Sakmann, *Konstruktion* 18, No. 7, 278-283 (1966). Some laws of motion are discussed. Graphs and simplified formulae are provided to determine cam parameters. A computer program is given to fabricate master cams on normal or numerical controlled milling machines. An analysis of dynamic and kinematic effects of cam motion, by varying the follower roller diameter on given cams, is also presented. The application of this method is illustrated by an example of a torque compensator.

Cost Estimating Becomes Less of an Art . . . And More of a Science, J. F. Kelly, *Production* 58, No. 6, 174-177 (December 12, 1966). Cost estimating is an important feature of the manufacturing process, and one in which consistency and accuracy can be critical features in business transactions. Increasing pressure on manufacturing facilities and a shortage of skilled estimators makes some form of automation necessary in this area. A computerized system of estimating which makes use of a "conversational" optical image terminal was developed to meet this need. Images are displayed on a screen, and the engineer can "talk" back and forth with the computer, entering information by means of a photosensitive light pen. There is real-time turnaround with documentation via an output typewriter. The manufacturing engineering task is accomplished in 20% of the time formerly required. The terminal is at present operating with a 1620 MOD II, but a link is planned with SYSTEM/360 MOD 30 and up, on a multiple programming basis. The control or supervisor programs, developed by a scientific programming group, are written in a symbolic instruction language, while the processing programs which the engineer can develop to fit his own requirements employ FORTRAN. Estimating accuracy is predetermined and built into the computation logic of the program.

Cut the Noise out of Your Next Article, D. E. Olson, *Electronic Design* 15, No. 6 (March 15, 1967). Good communication is a state of mind. You can communicate, if you put your mind to it. What is the purpose of your article? Why are you writing it in the first place? What is your main concept? Put the most important points first. Consider your writing job as you would any design task. A published article is one part of an information link. The information source is your storehouse of knowledge on the subject and the references you will use for your article. The transmitter is, of course, you, the author. The channel is the medium you select. The receiver of the signal you send is your reader and it is he who will apply the new knowledge you impart. To help the reader get the point, you must eliminate all interference, which is anything that hinders his understanding of the subject. Interference may be a missing signal: if you have not supplied the reader with all the details, he will be forced to supply the missing ones himself—and he may do so wrongly. Interference may be a term he does not understand, a formula or drawing that is not clear, or just plain involved writing. Your job is to design into your system the lowest possible interference level to ensure maximum signal reception.

Cyclic Codes in Multiple Channel Parallel Systems, K. Y. Sih and M. Y. Hsiao, *IEEE Transactions on Electronic Computers* EC-15, No. 6, 927-930 (December 1966). The well-known cyclic error-correcting codes are used so far only for serial systems; that is, systems having a single channel with information transmitted one bit at a time. In data-processing equipment and communication systems, information is often transmitted serially by characters and parallel by bits within a character. That is, there are several channels in parallel. Error correction in the existing multiple channel systems has been restricted to the use of block codes with the block length equal to the number of channels. The use of cyclic codes will allow the length of a code word many times greater than the number of parallel channels. This offers simple mechanization and, at the same time, reduces the redundancy of the system. In this note we present a method of design and implementation of cyclic codes in multiple channel systems. The codes have the same algebraic structure as in the serial systems. The method is based upon a serial-to-parallel transformation of linear sequential circuits, in which the transfer matrix of the circuit plays a key role.

Development Trends of the Logic Devices of Electronic Computers, O. G. Folberth, *Elektronische Rechenanlagen* 8, No. 4, 175-180 (1966). The first part covers the present state-of-the-art of the transistor technology and also gives an estimate of the limits of this technology. It follows a discussion of technologies where the transistor is not the basic element. And finally, some partially speculative ideas are presented concerning the future development particularly considering transistors at very low temperatures.

Device and Array Design for a 120-Nanosecond Magnetic Film Main Memory, E. W. Pugh, V. T. Shahan, and W. T. Siegle, *IBM Journal of Research and Development* 11, No. 2, 169-178 (March 1967). Device and array design considerations are described for a manufacturable 120-nsec cycle magnetic film memory containing 600,000 bits in the basic operating module. Worst-case testing is done in such a way as to provide quantitative values for such effects as adjacent bit-line stray field, ground-plane current spreading, flux trapping in metallic ground planes and strip lines, and magnetic-keeper efficiency. Worst-case output signals exceeding 3.8 mV are achieved with a 8-nsec rise-time word pulse of 510 mA. Bit current is 100 mA.

Digital Simulation Applied to a Photo-Optical System, R. B. Edwards, D. T. Hodges, Jr.,* W. D. Hopkins, and D. P. Paris, *IBM Journal of Research and Development* 11, No. 2, 189-194 (March 1967). The validity of the Image Forming Systems Simulator, IMSIM/1, as a means of simulating multiple-stage photo-optical systems has been determined. IMSIM/1 was used to simulate a three-stage system consisting of a microfilm camera (first stage), followed by the photo-optical subsystem of a developmental image storage and retrieval system (second and third stage). Fine line targets were processed through the camera and the storage and retrieval system. Microdensitometer scans of the targets were then processed through the simulator. To compare the output of the real system with the output of the simulator, it was necessary to measure carefully those system and camera data used in the simulator. After this was done, a satisfactory agreement between experimental result and simulator output was achieved.

* Cornell University, Ithaca, New York.

Discrete-State Feedback—A Route to Minimum Control, R. H. Thomas and P. P. Tong, *Instrumentation Technology* 14, No. 4, 59-61 (April 1967). Discrete-state feedback takes place in a non-continuous and time-independent manner. More specifically the feedback occurs only when the state variable under consideration experiences a prescribed change or reaches a predetermined value. This differs from continuous and sampled-data feedback. Discrete-state feedback emphasizes the concept of minimum control and is attractive for digital machines because the control function is essentially a digital sequential process. A logical method (flowchart) is described which will assist the control engineer in deciding whether discrete-state feedback is the technique to use for a particular application. Using a printed circuit motor for a high-speed incrementor as a design example, the reader is shown step by step how to utilize this technique.

Dynamic Mechanism Reliability by Monte Carlo Methods, F. R. Van Wagner, *Eighth Annual ASQC West Coast Reliability Symposium*, 71-83 (February 18, 1967). The Monte Carlo method provides a way of evaluating a complex reliability formula which would defy ordinary analytic approaches in all but a handful of trivial cases. The formula itself, derived by a technique called conditional convolution, gives the exact probability that a randomly constructed mechanism can perform a given task N times with R or fewer failures. Two computer programs, one a general-purpose Monte Carlo simulator, have been developed to handle the computations. They have been applied many times by IBM engineers to design-reliability problems with proven success.

Effects of MTF Shapes on Preferences Among Typewritten Reproductions, C. K. Clauer and R. L. Erdmann, *Photographic Science and Engineering* 10, No. 6, 326-333 (November-December 1966). Comparative preferences of typewritten reproductions were determined for original and third carbon documents with the reproducing modulation transfer function (MTF) shape and spatial frequency scale factor as independent variables by using four different ranking tasks. Rank discrimination was excellent with each of the MTF shapes for scale factor steps of about 10 percent. Considerable variability resulted when all five MTF shapes were compared at equal scale factors. Comparisons between the two extreme MTF shapes reversed as scale factors were increased. The original document scale factor equivalents of the carbon document scale factors were also determined for each MTF shape.

Estimating Flight Time for Optimum Trajectories, R. L. Duty, *IEEE Transactions on Aerospace and Electronics Systems* AES-3, No. 2, 179-185 (March 1967). Various methods are presented for estimating the flight time for vehicles that fly an optimum trajectory. A realistic example is considered in order to display the inherent accuracy of each of these methods. Numerical integration methods are found to be the most accurate. Simple formulas are derived for the case where a less accurate estimate is acceptable. All of these methods require less computation than would be required in order to solve the overall optimization problem. Thus, any one of these methods can be applied to an on-board guidance scheme or control system that requires a real-time estimate of the time-to-go.

An Experimental Investigation of a Mixed-Font Print Recognition System, C. N. Liu and G. L. Shelton, Jr., *IEEE Transactions on Electronic Computers* EC-15, No. 6, 916-925 (December 1966). This paper discusses an experimental study of a mixed-font print recognition system. With a program-controlled CRT scanner input, using 96 *N*-tuple recognition measurements with ternary minimum distance decision, the system reported is capable of reading a variety of type styles at a performance level which is quite acceptable for fair to good quality print. Performance is marginal for poor quality print.

Experimental Studies in Speaker Verification Using an Adaptive System, K. P. Li, J. E. Dammann, and W. D. Chapman, *The Journal of the Acoustical Society of America* 40, No. 5, 966-978 (November 1966). This paper describes an investigation of the capability of a two-level adaptive linear threshold element (LT ϵ) system to perform speaker discriminations. The study also includes an investigation of discriminating a speaker from an unknown population. The problem has been confined to the verification of an utterance as that of an expected informant. The environment of the experiments is discussed, and the experimental system is described. At the first level LT ϵ , four different kinds of training have been developed for effective transformation and data reduction. At the second-level LT ϵ , different training conditions and different decision processes are investigated and evaluated. Over 90% accuracy is obtained in separating a known speaker from imposters.

Factors to Consider in Selecting and Using Lenses in Optical Systems, A. D. Bates, *Proceedings of Seminar on Photographic Systems for Engineers, Society of Photographic Scientists and Engineers*, 103-129 (May 1966). This tutorial discussion, directed to engineers with a general understanding of optical principles, emphasizes interactions among variables that affect lens performance in optical systems.

A High Speed Associative Memory, A. W. Bidwell and W. D. Pricer, *Digest of Technical Papers, 1967 International Solid-State Circuits Conference*, 78-79 (February 1967). This paper describes a simple associative memory cell as used in a high speed 8-word experimental model with 15 nsec interrogate delay and in an experimental time-sharing system of 64 words.

A Very-High-Speed, Nondestructive-Read Magnetic Film Memory, G. Kohn, W. Jutzi, Th. Mohr, and D. Seitzer, *IBM Journal of Research and Development* 11, No. 2, 162-168 (March 1967). A very-high-speed thin magnetic film memory has been designed and built as a cross sectional model for 140,000 bits. It can be operated in the NDRO mode with a 20-nsec read cycle time and a 30-nsec access time, and it can be read 65 nsec after the beginning of a write operation.

Integrated Computer Circuits—Past, Present, and Future, R. A. Henle and L. O. Hill, *Proceedings of the IEEE* 54, No. 12, 1849–1860 (December 1966). Since 1960, computer circuits have evolved from discrete components to hybrid or integrated circuits, allowing an order of magnitude improvement in cost and reliability. Continuation of these trends points toward the availability of large-scale integration, with 100 or more circuits per chip, by 1970. Timely achievement of this potential improvement depends on increased interaction between system and device designers and reduction of costs associated with engineering changes and field stocking. The dominant role of the bipolar device is presently being challenged by the field effect device. Optical and bulk effect devices may have future application in the digital area.

Low Cost General Purpose Computer for Missile Guidance, W. N. Carroll and F. F. Jenny, *Electronics* 40, No. 5, 171–176 (March 6, 1967). The article describes the performance of a general purpose digital computer which alters the historical economic advantage that analog, hybrid, and incremental computers have enjoyed in missile guidance applications. Through the use of monolithic integrated circuits, mass produced high speed core memories, low cost packaging techniques, and an optimized organization, the computer promises to provide greater performance, flexibility, and reliability at equal or lower cost than traditional approaches.

A Note on the Quantum-Statistical Brillouin-Wigner Perturbation Theory, P. Erdos and K. P. Jain, *Physics Letters* 24A, No. 2, 123–124 (January 16, 1967). The Brillouin-Wigner form of quantum statistical perturbation theory is developed. This gives a better convergence to expansions used to calculate the thermodynamic functions of many-particle systems. The method is demonstrated on the linked-cluster expansion for the free energy of a system of conduction electrons interacting with a magnetic ion.

Numerical Evaluation of Wiener Integrals, A. G. Konheim and W. L. Miranker, *Mathematics of Computation* 21, No. 97, 49–65 (January 1967). A systematic study of quadrature formulae for the Wiener integral $\int F[x]w(dx)$ of the type $\int F[\theta(u, \cdot)]v(du)$ is presented. The Cameron and Vladimirov quadrature formulae, which are the function space analogues of Simpson's Rule, are shown to fit into this framework. Numerical results are included.

A 110-Nanosecond Ferrite Core Memory, G. E. Werner, R. M. Whalen, N. F. Lockhart, and R. C. Flaker, *IBM Journal of Research and Development* 11, No. 2, 153–161 (March 1967). The design of a large, very-high-speed ferrite memory is described. The memory has a capacity of 8192 words, 72 bits per word, and has a cycle time of 110 nanoseconds and an access time of 67 nanoseconds. The storage devices are miniature ferrite cores, 0.0075 by 0.0123 by 0.0029 inches, and are operated in a two-core-per-bit destructive read-out mode. A planar array geometry with cores resting on a single ground plane is used to control drive line parameters. Device switching speed and bit line recovery are treated as special problems. The design criteria and operational characteristics of the core, and the approach taken on the bit line recovery problem, are also presented.

Optical Reader is not Affected by Light Intensity Variations, N. D. Kline, *Electronic Design* 15, No. 4, 112–113 (February 15, 1967). A circuit is described which will produce an output voltage directly proportional to the contrast ratio of the input voltage. The circuit can be used in mark sensing machines or in applications where the output is compared to a preset threshold for switching purposes or where the output is compared to select the channel with the maximum output voltage or contrast ratio to aid in distinguishing erasures.

Properties of a Model for Parallel Computations: Determinacy, Termination, Queueing, R. M. Karp and R. E. Miller, *SIAM Journal of Applied Mathematics* 14, No. 6, 1390-1411 (November 1966). This paper gives a graph-theoretic model for the description and analysis of parallel computations. Within the model, computation steps correspond to nodes of a graph, and dependency between computation steps is represented by branches with which queues of data are associated. First, it is shown that each such *computation graph* G represents a unique computation, determined independently of operation times. Next, methods of determining whether such a computation terminates and of finding the number of performances of each computation step are developed. The maximal strongly connected subgraphs of G and the loops within these subgraphs play a central role in this analysis. For example, use is made of the result that either every computation step within a strongly connected subgraph of G is performed an infinite number of times, or none is. Finally, necessary and sufficient conditions for the lengths of data queues to remain bounded are derived.

Read-Only Storage in Digital Computers, von H. Painke, *Elektronische Rechenanlagen* 8, No. 1, 23-27 (February, 1966). Read-only storage is widely used in the controls of modern computers. Since its access time is in the range of 100 to 200 nanoseconds, even complex jobs may be executed in a serial rather than a parallel mode of operations which results in a simpler structure of the computer. There are two types of read-only storage used in modern computers. The basic principles of their operation as well as the technical realization of those principles are discussed in this article. A simple data flow and micro-program model illustrates the principles of microprogramming and the reduction in structure that can be achieved by using read-only storage.

Rolle und Bedeutung formeller Sprachen bei der industriellen Automation, (Use of formal languages in the industrial automation process), H. Zemanek, *Elektrotechnik und Maschinenbau* 83, No. 6, 463-469 (1966). Considered are formal languages as a means for describing industrial manufacturing processes. The historical background and the main principles for designing formal languages are outlined. Some of the existing formal languages for computing processes (ALGOL, FORTRAN, COBOL) and for Automatically Programmed Tools (APT) are discussed.

SCEPTRE Gives Designers New Power, S. R. Sedore and J. R. Sents, *Electronic Design* 15, No. 6, 230-234 (March 15, 1967). The article outlines the progress which has been made recently in the development of automatic transient analysis programs. Electronic equipment has become so complex that the analysis of its operation cannot be accomplished manually. Digital computers have become powerful tools for resolving such problems, but the proper use of a digital computer is also a complex problem. The circuit analysis program, SCEPTRE, bridges the gap between the design engineer and the computer.

Semiotics and Programming Languages, H. Zemanek, *Communications of the ACM* 9, No. 3, 139-143 (1966). The term pragmatics and the notion are traced back in history: the definitions of MORRIS for the semiotic dimensions are given and the contribution of the "Wiener Kreis" is described. Relationships of semiotics to other aspects of language theory are treated. A definition of the notion of a language and a programming language in particular is tried and the reasons for artificial formal languages are given. The borderlines between the semiotic aspects are traced and the different possible fields in pragmatics of programming languages are outlined.

Simulation Provides Real-Time Representation of Missile Missions, P. A. Kilty, *Simulation* 7, No. 5, 224-226 (November 1966). The man-in-the-loop simulator provides the operator with real-time representation of simulated missile missions. Simulation is provided for actual sensor operation against simulated targets, control and monitoring of the missile flight by an operator, and continuous evaluation of the accuracy and effectiveness of the system.

Spiraling Scanner Reads Handwritten Letters, M. D. King, *Machine Design* 38, No. 30, 36 (December 22, 1966). A detailed description of the IBM 1287 Optical Reader is presented as a "design in action." The 1287 uses optical scanning and character recognition circuitry to read any combination of hand-printed, machine printed, or pencil marked numbers directly into a SYSTEM/360 computer. This on-line input device reads, feeds, and stacks a wide range of documents. It is the first commercially available machine capable of reading handwritten numbers and certain alphabetic characters.

Two Statistical Evaluation Criteria for Predicting Performance of Microelectronic Circuits, D. B. McKay, *Semiconductor Products and Solid State Technology* 10, No. 3, 55-58 (March 1967). Two statistical design techniques—the Monte Carlo method and the direct calculation method—are described as they relate to microelectronic circuit design parameters (transistor V_{BE} and Beta variations, resistor values, etc.). The method for implementing these two techniques is reviewed for a number of sample circuits. A technique known as "tracking" is also included in mathematical form for a simple transistor circuit. Two generalized program flowcharts are included as a guide for predicting and verifying dc design techniques applied to ac performance.

System Performance Evaluation: Survey and Appraisal, P. Calingaert, *Communications of the ACM* 10, No. 1, 12-18 (January 1967). The state of the art of system performance evaluation is reviewed and evaluation goals and problems are examined. Throughput, turnaround, and availability are defined as fundamental measures of performance; overhead and CPU speed are placed in perspective. The appropriateness of instruction mixes, kernels, simulators, and other tools is discussed, as well as pitfalls which may be encountered when using them. Analysis, simulation and synthesis are presented as three levels of approach to evaluation, requiring successively greater amounts of information. The central role of measurement in performance evaluation and in the development of evaluation methods is explored.

A Systems Approach to N/C Machining, L. F. Knappe and J. J. Harvey, *Production* 58, No. 6, 138-141 (December 1966). The practical application of computer-aided design systems to N/C machining is described using a cam case study and a model part study. Such design systems enhance the ability of the user to respond to changing and critical needs for parts during the development phase, pre-production phase, production phase, or at a later time for replacement of parts. The cost is usually less than for parts produced by conventional methods and the quality is consistently good.

3-D Imagery and Holograms of Objects Illuminated in White Light, R. V. Pole, *Applied Physics Letters* 10, No. 1, 20-22 (January 1, 1967). Described is a method of obtaining holograms of 3-D objects illuminated in white light. First, a 3-D scene, illuminated in white light, is photographed through a fly's eye lens. If this photograph is projected through the same lens it yields a real 3-D image of the object directly. However, by using coherent light for projection, this real image can be used to make a hologram, which in turn yields both a real and a virtual image of the object.

The Theory and Computation of Knapsack Functions,* P. C. Gilmore and R. E. Gomory, *Operations Research* 14, No. 6, 1045-1074 (November-December 1966). In earlier papers on the cutting stock problem we indicated the desirability of developing fast methods for computing knapsack functions. A one-dimensional knapsack function is defined by:

$$f(x) = \max \{ \Pi_1 Z_1 + \dots + \Pi_m Z_m; l_1 Z_1 + \dots + l_m Z_m \leq x, Z_i \geq 0, Z_i \text{ integer} \}$$

where Π_i and l_i are given constants, $i = 1, \dots, m$. Two-dimensional knapsack functions can also be defined. In this paper we give a characterization of knapsack functions and then use the characterization to develop more efficient methods of computation. For one-dimensional knapsack functions we describe certain periodic properties and give computational results.

* This research was supported in part by the Office of Naval Research under Contract No. Nonr 3775(00).

A Time-Sharing System Using an Associative Memory, A. Ba. Lindquist, R. R. Seeber, and L. W. Comeau, *Proceedings of the IEEE*, Special Issue on Computers 54, No. 12, 1633-2034 (December 1966). The hardware scheme designed to implement an experimental IBM SYSTEM/360, MODEL 40 time-sharing system will be discussed. The concept of a virtual system will be introduced which allows up to fifteen simultaneous users on the system, each user assuming he has a complete hardware-software of his own. The problem of building and interfacing a 64-word associative memory mapping device into an existing hardware system will be reviewed.

A Vestigial-Sideband FM Modem, E. Hopner, R. W. Calfee, and L. P. West, *Telecommunication Journal* 34, No. 2, 55-66 (February 15, 1967). An experimental vestigial-sideband FM modem has been developed that is capable of 4800-baud operation over readily available leased telephone lines, while also allowing 1200-baud binary double-sideband FM operation over switched networks, the standard recommended for international data transmission by the CCITT. Analog signals, which would be required for facsimile document transmission and other applications, can also be transmitted with the proposed modem. The vestigial-sideband FM process is described, with details of the three-level coding that allows the high data rate over a limited bandwidth. Test results are cited which verify the high-speed capability.

The following papers are from a special series which appeared in the March 1967 issue of the *IBM Journal of Research and Development*.

On the Partial Difference Equations of Mathematical Physics,† R. Courant,* K. Friedrichs,* and H. Lewy,** *IBM Journal of Research and Development* 11, No. 2, 215-234 (March 1967). Problems involving the classical linear partial differential equations of mathematical physics can be reduced to algebraic ones of a very much simpler structure by replacing the differentials by difference quotients on some (say rectilinear) mesh. This paper will undertake an elementary discussion of these algebraic problems, in particular of the behavior of the solution as the mesh width tends to zero. For present purposes we limit ourselves mainly to simple but typical cases, and treat them in such a way that the applicability of the method to more general difference equations and to those with arbitrarily many independent variables is made clear. Corresponding to the correctly posed problems for partial differential equations we will treat boundary value and eigenvalue problems for elliptic difference equations, and initial value problems for the hyperbolic or parabolic cases. We will show by typical examples that the passage to the limit is indeed possible, i.e., that the solution of the difference equation converges to the solution of the corresponding differential equation; in fact we will find that for elliptic equations in general a difference quotient of arbitrarily high order tends to the corresponding derivative. Nowhere do we assume the existence of the solution to the differential equation problem—on the contrary, we obtain a simple existence proof by using the limiting process. For the case of the elliptic equations convergence is obtained independently of the choice of mesh, but we will find that for the case of the initial value problem for hyperbolic equations, convergence is obtained only if the ratio of the mesh widths in different directions satisfies certain inequalities which in turn depend on the position of the characteristics relative to the mesh.

† This paper, which originally appeared in *Mathematische Annalen* 100, 32-74 (1928), is republished by permission of the authors.

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Hyperbolic Difference Equations: A Review of the Courant-Friedrichs-Lewy Paper in the Light of Recent Developments, P. D. Lax,* *IBM Journal of Research and Development* 11, No. 2, 235-238 (March 1967). The portion of the Courant-Friedrichs-Lewy paper (*Math. Ann.* 100, 32 (1928)) that was devoted to hyperbolic difference equations is critically reviewed in terms of its basic contribution to the numerical solution of partial differential equations. Some subsequent developments are then discussed, including recent literature related to the von Neumann condition, some irreversible schemes, generalizations of the energy method, some new difference schemes, and mixed initial boundary value problems.

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Elliptic Equations, S. V. Parter,* *IBM Journal of Research and Development* 11, No. 2, 244-247 (March 1967). A brief review is given of the literature on numerical methods for elliptic problems as related to the ideas introduced by Courant, Friedrichs, and Lewy in the fundamental paper published in *Math. Ann.* 100, 32 (1928). The discussion shows how the finite-difference methods have subsequently been extended and applied to higher order elliptic problems and how the recent literature has reported methods for solving large algebraic systems. In addition, there is a discussion of the relation between the Dirichlet problem and the problem of the random walk.

On Difference Methods for Parabolic Equations and Alternating Direction Implicit Methods for Elliptic Equations,† O. B. Widlund,* *IBM Journal of Research and Development* 11, No. 2, 239-243 (March 1967). Some aspects are discussed of the development of the theory of difference approximations to parabolic equations in its relation to the basic development of difference methods for hyperbolic and elliptic equations by Courant, Friedrichs, and Lewy, *Math. Ann.* 100, 32 (1928). The present paper also deals with the related problem of establishing the convergence of alternating direction implicit methods for elliptic problems.

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